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CERTAIN PHYSICO-CHEMICAL CHANGES IN SOILS CAUSED BY CONTERMINATION OF PETROLEUM OIL IN SOME MASEV COMMUNITIES IN BENUE STATE, NIGERIA

[1]*S. O. Odoemena;[2]*E. A. Olowolafe and[1]*E. A. Igomu

1 Department of Soil Science, University Of Agriculture Makurdi, Nigeria
2 Department of Geography and Planning, University Of Jos, Jos Nigeria

ABSTRACT

The Nigerian National Petroleum Corporation (NNPC) oil pipeline project has left its mark in form of environmental problems in some Masev Communities of Benue State. An extensive area of prime agricultural land has been affected. Spilled petroleum oil is certainly responsible for alterations of soil physico-chemical properties. From five selected communities which had experienced oil spill, twenty four soil samples were collected at oil spill sites at depth 0-15 cm (surface soils) and twenty four others at depth 15-30cm (subsoils). A similar exercise of soil sample collection was done at three selected sites from three communities, within the same geographical area, unaffected by oil spill. Soil chemical and physical property analysis was carried out in the Benue State Water Board Laboratory Makurdi for the affected and non-affected areas to assess the extent to which the soil in the affected areas had been affected by the project. The results of the tests were analyzed using some statistical methods. The result of the analysis showed that the soils in the affected areas were significantly contaminated by oil spillage from the NNPC pipeline and this, in turn had affected the agricultural productivity and biodiversity within the communities. The laboratory results were based on FEPA standards. It has been suggested that there is an utmost necessity to take some perfect steps either to control or to minimize the petroleum oil pollution in this area.

Keywords: Benue State, Masevcommunities, NNPC, oil spill, physico-chemical properties, oil pipeline, soil contamination

Introduction

Oil spills involve the unintentional release of dangerous hydrocarbons such as benzene and poly-nuclear aromatic hydrocarbons into the soil and water sources. Oil spills affect vast stretches of land and waterways thus polluting not only crops but also marine life and the sources of water for domestic uses. As the spill occurs, it spreads onto farmlands and water

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bodies. The toxic petroleum oil seeps into the grounds and is taken up by the roots of plants. Recent studies have shown that oil spills lower soil fertility and cause poor growth of plants (Pyagbara, 2007; Osuji and Nwoye, 2007; Omeka *et al*., 2010; Uzoije and Agunwanba, 2011; and Wikipedia, 2011). Contaminated sites by hazardous substances are major environmental concerns throughout the world, because most contaminants can persist for many years in soil and sediments, where they have the potential to adversely affect human health and the environment.

Petroleum oil is not a single chemical but a collection of hundreds of widely different properties and toxicities and when mixed with soil, it brings about some physico-chemical changes in the soil (Barua *et al*., 2011) which in turn are deleterious to the growth and development of plants grown in such a soil. Oil spills effect soil in two ways; It may penetrate into the soil, where it directly affects plant root system, microbial population and oxygen content. Petroleum oil in soil makes the soil condition unfavourable for plant growth (Jong, 1980) due to the reduction in the level of available plant nutrients ora rise in toxic levels of certain elements such as iron and zinc (Udo and Fayemi, 1975). There are several vegetal species that are capable of growing in soils polluted with hydrocarbons and they participate in their degradation through the rhizosphere, which favours the growth of several microorganisms' species and increases biomass and microbial activities, accelerating degradation processes (Barua*et al*., 2011). It could cause nutrient immobilization as the oil creates some conditions in soil, which make some vital nutrients unavailable to plants (Agbogidi, 2011). Cases of nutrients immobilization in soils treated with polluted petroleum hydrocarbons have also been reported by Benka-Coker and Ekundayo (1997); Ekundayo and Obuekwe (1997) and Agbogidi and Ejembi (2005). Similar reports have been made by Sharma *et al*., (1989), Gill *et al*., (1992) and Bamidele and Agbogidi (2011).

In Nigeria Oil and gas pipeline projects are known as possible sources of environmental degradation due to rising rates of vandalism and some physical causes. Petroleum oil pollution is a regular phenomena in the oil drilling sites as well as the areas through which oil transportation pipelines carry the crude oil either to the oil collecting stations(deports) or to the oil refineries. Generally some scholars have studied the environmental effects of some oil projects in Nigeria. This has been mainly within the Niger Delta or parts of the rain forest areas of the country (Osuji and Onojake, 2004; Atubi and Anokala, 2006; Anifowese, 2008; Akpofure *et al*., 2000; Abii and Nwosu, 2009; Agbogidi and Egbuchua, 2010). Survey of literature reveals that verylittle and scattered information is available of petroleum oil pollution on soil environment within the study area (Idoga *et al*.,2005;The Directorate of Environment, Ministry of Water Resources and Environment, Benue State, 2011).

The objective of this study was therefore to determine the changes in the physico-chemical properties of soils in some petroleum oil affected communities along the NNPC oil pipeline within the Masev area of Benue State in Nigeria.

MATERIALS AND METHODS

The study area is located within latitudes $7^0$15' N and $7^0$39' N and longitudes $8^0$13'E and $8^0$37'E, and covers the communities within the stretch of NNPC oil pipeline from Shawa, (near Taraku) to Apir Depot (near Makurdi). This is part of the Enugu - Makurdi section of the NNPC oil pipeline within the Port Harcourt region (Figure 1). This stretch of the underground oil pipeline of about 48km traverses the Ugee, Mbalom and Mbasombo council wards within the Masev area in Gwer Local Government Area (LGA) of Benue State(Figure 2). The Masev area is made up of the thirteen local council wards (LCW) of Gwer LGA in Benue State. The area is mainly made up of rural settlements engaged in agricultural activities such as, cropping, fishing, and hunting. The local people, mostly depend on the natural environment for their livelihood. This underground pipeline passes through ecologically fragile Guinea Savanna areas (Idoga *et al*., 2005). The project therefore threatens valuable ecosystems in the areas.

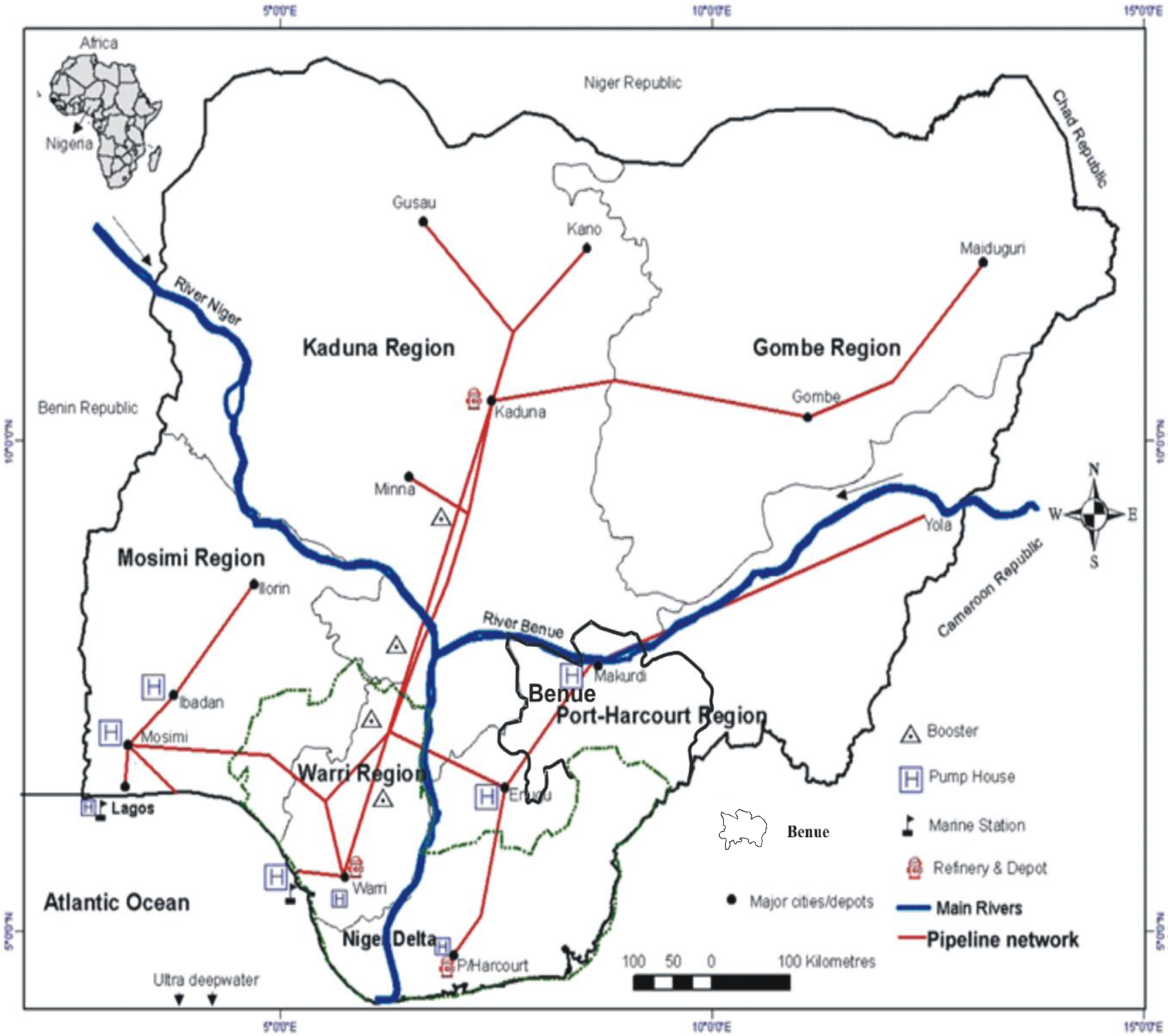
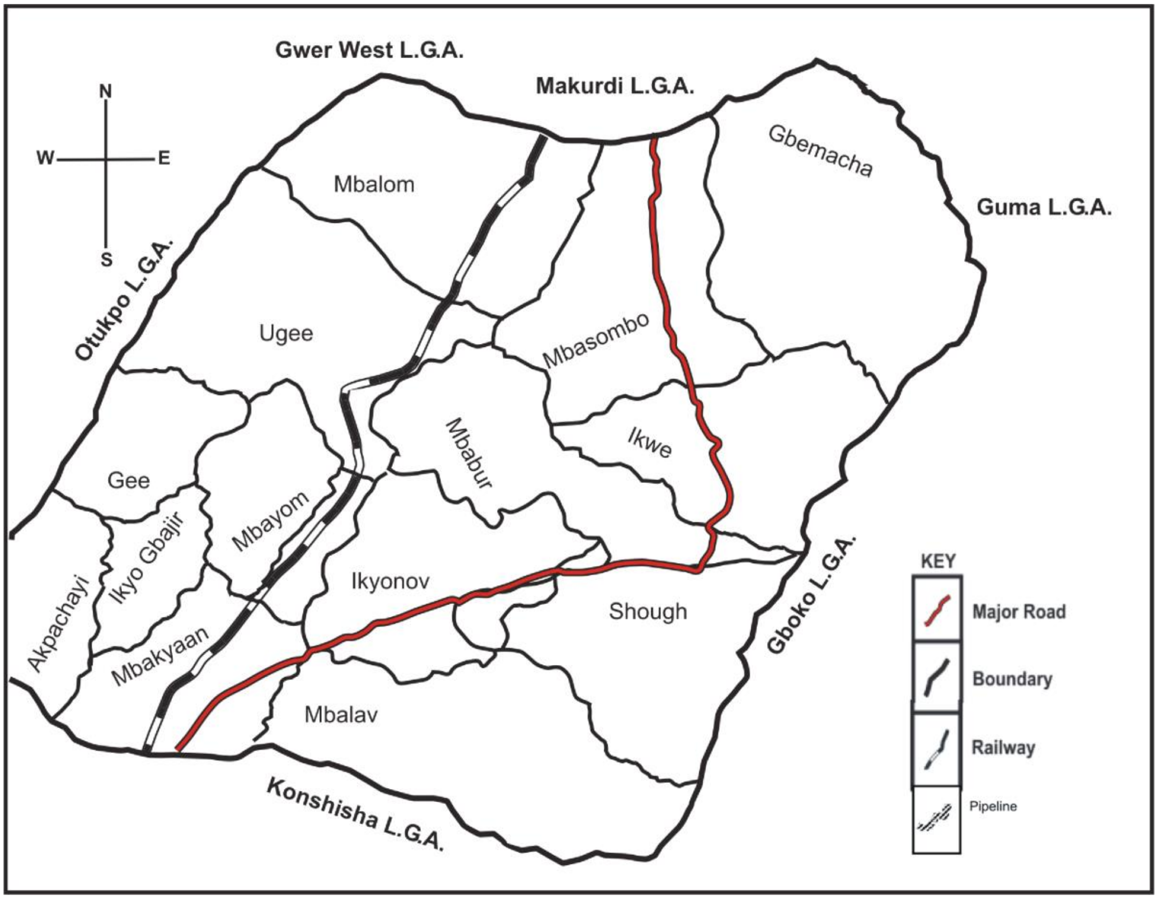


Fig 1: Map of Nigeria showing the Downstream Pipeline System (DPS) and infrastructures, Benue State and the NNPC/PPMC geographic regions of operation.

Sources: Moderated after NNPC. (2010)

Fig 2:



Sketch of Gwer L.G.A. indicating the Wards affected by the NNPC oil pipeline project. Source: Gwer L.G.A. Health Department, Benue State. **Scale: 1:106000**

Selection of sample areas and Sampling

Communities or locations for soil sample collection within the pipeline affected areas were carefully selected among those that had experienced oil-spill within the Ugee, Mbalom and Mbasombo council wards (Fig. 2). This was based on data collected during a field reconnaissance survey (Odoemena, 2014). They are Tse Ugesa Mbalim in Ugee L.C.W., Anshua Mbasada and Tse Ber Turan in Mbalom LCW and Tse Agula Mbamar and Orwuatsaga Mbagbar in Mbasombo LCW. Soil sample collection sites were also selected from the following communities within the same geographical region, but which had not experienced any oil spill (control sites): Genyi Mbalim in Ugee LCW, Ayar in Mbalom LCW and Tse Tsuwe Mbakor in Mbasombo LCW.From the five selected communities which had experienced oil spill, twenty four soil samples were collected at oil spill sites at depth 0-15cm (top soil) and twenty four others at depth 15-30cm (sub soil) (the maximum rooting zone for most vegetable crops) with

Vol. 2, No. 05; 2017

ISSN: 2456-8643

improved soil augur (Pasquini, 2006). A similar exercise of soil sample collection was done at the three selected sites from the non-affected areas. The soil samples from the oil pipeline project affected sites were designated AS^t for the surface soils and AS^s for the sub soils. Those from control sites were designated CS^t and CS^s, for the surface and sub soil samples, respectively. Similarly, three soil profile pits were dug for further soil investigation at designated sites. The first pit (PA_1) was dug at a spillage site at Anshua Mbasada in Mbalom Council Ward (Plate 1), while the second pit (PA_2) was dug at a spillage site at Tse Agula Mbamar in Mbasombo Council Ward (Plate 2). The third soil profile pit (PU) was dug at Genyi Mbalim in Ugee Council Ward as the sample site for unaffected areas (control). Soil samples were stored in labeled plastic bottles. The collection points were named after the nearest villages to them.

Physical Properties: The physical properties of soil are those responsible for the transport of air, heat, water and solutes through the soil. Several physical properties are affected by management or introduction of pollutants. They often deteriorate the soil as pollutions, thereby rendering the soil less permeable and more susceptible to run-off and erosion losses.

Plate 1: *Oil Spill site at Anshua*

Plate 2:*Oil Spill site at Tse Agula*

Soil physico-chemical Characteristics

The following physico-chemical characteristics of soils were determined; percentages of sand, silt and clay, soil texture, soil colour, electric conductivity, temperature, and pH. Others were the concentrations of organic matter, total nitrogen, phosphorus, hydrocarbon, exchangeable bases (Ca, Mg, K and Na), exchangeable acidity, available P, Cu, heavy metals (Fe, Pb Ni, Cd, Cr). The analysis was carried out at the Benue State Water Management Board laboratory following appropriate scientific methods as described below.

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The representative samples were taken to the laboratory, air dried, sieved through 2 mm sieve and stored in plastic bags for analysis. The laboratory tests were carried out following HACH (1991), APHA, (1992) and Agunwamba (2001) prescriptions. A t- test was carried out to measure the significance of the test results for the oil spill affected and unaffected areas

RESULTS AND DISCUSSIONS

The physico-chemical properties of soil in this study are given in Tables 1 and 2 for the top soil and sub soil samples, Tables 3and 4 for the samples from the soil profile pits.

Surface and sub soil investigations.

The t test results for surface soil samples, (Tables 1 and 2), showed a significant difference in the values of % sand, % silt, soil temperature, moisture content, electric conductivity, Zn, Fe, OM, P, Pb, Na, Ea, THC, Ni, Cd, and OM in the oil spill affected and control samples because in each case $t_{stat} > t_{crit}$. The test results also showed no significant difference in the values of K, Ca, CEC, NO_3-N, Mg, % clay and pH in the surface soil samples because in each case $t_{stat} < t_{crit}$. The t-test results for sub soil samples showed that there was every reason to believe that there was significant difference in the values of THC, Zn, Fe, P, Pb Cu, Ni, Cd, OM, and EC, %Sand, %Silt, temperature and moisture content in the affected and control samples because, in each of the cases $t_{stat} > t_{crit}$.

The analysis also showed no significant difference in the values of K, Ca, CEC, Na, NO_3-N, Mg, Ea, % Clay, and pH in the surface soil samples, because in each case $t_{stat} < t_{crit}$.

The results of the soil analysis of the surface and sub soil samples are presented in Tables 1 and 2 and explained below. There was no significant difference in the values of pH of both surface and sub soil affected samples and those of the control samples. The texture of the soil in the study area was predominantly clayey. The mean of moisture content from the affected areas were 7.46% surface and 9.89% sub soils. Whereas those from the unaffected areas were 4.24% surface and 7.06% sub soils (Tables 1). Electrical Conductivity (EC) is a measure of ionic concentration in the soil and is therefore, related to dissolved solutes. EC was significantly higher in the oil spill affected soils than in the control soil samples. Electrical Conductivity (EC) is a measure of ionic concentration in the soil and is therefore, related to dissolved solutes. Tables 2 and 4 show that EC was relatively higher in the oil spill affected soils. It is not likely that the released oil was directly responsible for the observed changes in EC since organic compounds like refined oil cannot conduct electrical current very well. It is likely that the EC for the control sites was different from the contaminated sites prior to contamination as earlier noted by some other authors (Osuji and Nwoye, 2007; Omaka *et al*., 2010). The mean of the hydrocarbon concentrations in the soil samples from both the affected and control sites were 4871.25 mg/kg for surface soils and 4518.3 mg/kg for sub soils, and 1.75 mg/kg for surface soils and0.72 mg/kg sub soils respectively. This was indication of high level of hydrocarbon contamination of the oil spill affected sites. The increase in the concentration of the Total Hydrocarbon Content (THC) noticed in the soil profile investigation (Table 4) in the oil spill affected soils explains the high level of hydrocarbon contamination of the oil spilled soils. This agreed with the report on the surface and sub soil investigations (Tables 1 and 2). A review of existing data by NDES (1999) and Osuji (2007) affirmed that such high hydrocarbon levels affect both ground and subterranean flora and fauna, which are essential adjuncts in the biogeochemical cycle that affects availability of plant nutrients. As hydrocarbons from oil-polluted soil accumulate in the chloroplasts of leaves, photosynthetic ability of the leaves becomes reduced. Various contaminants including petroleum oil, spent engine oil and heavy metals have been found to significantly affect the growth and performances of various plant species (Agbogidi, 2011). Studies have also shown that THC can be carcinogenic and/or mutagenic in some circumstances and have been classified as priority pollutant. This concentration, of contaminants could also increase the presence of toxic materials such as cresol, phenols, chlorine, which may inhibit the growth of the hydrocarbon oxidizers (Amellel *et al*., 2001).

Table 2 indicated that the mean valuesfor organic matter concentration obtained from the oil polluted sites (3.63 and 3.24% for surface and sub soils), were significantly higher than those obtained from the control sites (1.34 and 1.03% for surface and sub surface soils).The mean values of organic matter (OM) of the oil spill affected soil samples were significantly higher than those of the control samples (Tables 2 and 4). This agreed with the views of Osuji and Onojake (2006). This increase in OM in the samples from the oil spill affected areas may be attributed to the metabolic processes following oil spillage that facilitates agronomical addition of organic carbon from petroleum hydrocarbon by reducing the carbon mineralizing capacity of the micro flora. Organic matter contents of oil-polluted soil should normally increase following the addition of carbonaceous substances from oil pollution. This agreed with the report by Osuji and Nwoye (2007), Uzoije and Agunwanba (2011), and Barua *et al*., (2011).

The reduction in the concentration of NO_3 – N shown in Table 8 in the oil spill sites,(that is, 31.15 and 32.34 mg/kg for soils, in contrast to 52.14 and 53.35 mg/kg for surface and sub surface soils in the control samples), suggested that the process of nitrification might have reduced

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spillage. There was a significant decrease in the concentration of nitrates in the oil spill affected surface and sub surface following the incidence of oil samples (Tables 2 and 4). This suggested that the process of nitrification might have reduced following the incidence of oil spillage. (Odu *et al*., 1985; Uzuije and Agunwamba, 2011). This probably explained the relatively lower values of NO_3 – N obtained from the surface soil and soil profile samples from the oil spillage affected areas.

The concentration levels of calcium (Ca) were low in the affected areas (Tables 8). Calcium content mean were 7.00 and 4.72 mg/kg for surface and sub soil samples in the affected sites, and 17.32cmol$^{(+)}$/kg and 16.8cmol$^{(+)}$/kg for surface and sub soil samples in the control sites.The concentration levels of calcium (Ca) were lower in the oil-spill affected soils (Tables 2 and 4). The low calcium status of the oil spill affected samples could cause poor stem growth in plants and decolouration of crops and thus, low crop yield (Nwilo and Badejo, 2005). The yield of a crop is a complex trait affected by genetically controlled physiological components and other external factors like soil nutrients and climate (Agbogidi, 2011, Olowolafe and Dung, 2000).

Table 1 showed significant increase in the fraction of sand in the affected soils which were 39.93 and 40.91% for surface and sub soil samples for the affected areas, and 32.82 and 35.92% for the surface and sub soil samples for the control. Trace heavy metals (Ni, Fe, Cu, Cd and Pb) are normal constituents of oil (Osuji and Onojake, 2004). Table 2 indicated that the mean values of the concentrations of these heavy metals in samples of oil spill-affected soils were higher than those from the control samples. The effect of oil spill on Sodium (Na) concentration (Table 2) indicated slight contrast in affected areas in the surface and sub soil samples which was 1.43 and 1.49cmol$^{(+)}$/kg) in contrast to that in the control surface and sub soil samples (1.35and 1.28cmol$^{(+)}$/kg).The concentration of sodium (Na) was slightly higher in the samples from oil spill affected areas (Tables 2 and 4). This tends to show that oil deposition in soil increased the sodium content of the soil and so corroborating Odu's(1972) submissions.The concentrations of heavy metals (Ni, Fe, Cu, Cd, and Pb) were high in the samples from the oil spill affected areas (Tables 2 and 4).

Heavy metals are normal constituents of oil (Osuji and Onojake, 2004). The higher concentration of heavy metals in the soil samples affected by the oil pipeline project could be due to hydrocarbon pollution (NAS, 1975 and Uzuije and Agunwanba, 2011). For the same reason the concentration level of zinc was higher in the samples from oil spill affected areas.The increase in the concentration of cadmium (Cd) in oil spill affected samples could be as a result of contamination from petroleum products. As plants easily take up Cd from the soil, areas with

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higher cadmium concentrations could result in the plants accumulating Cd beyond the critical level for grains (Kitagishi and Yamane, 1981). Similarly, the increase in concentration of lead in the spillage-affected areas may be due to oil pollution. Normally, high concentration of lead in the soil limits the enzymatic activities of micro biota, thereby affecting the decomposition of organic substances (Woytowicz, 1980).

Cation Exchange Capacity (CEC) mean values of the oil spill affected samples were 14.64 and 9.89 cmol$^{(+)}$/kg for surface and sub soils, while those of the control samples were 25.20cmol$^{(+)}$/kg and 25.06cmol$^{(+)}$/kg for surface and sub soils respectively (Tables 2). This showed significant decrease in CEC in the affected soil samples. Cation exchange capacity (CEC) values were found to be higher in the control samples (Tables 2 and 4). The decrease in CEC values in the soil samples of the pipeline project areas could be as a result of oil contamination which reduces CEC and double coating of the soil (Mashal *et al*., 2009). The CEC of not more than 20mg/kg noticed in the oil spill affected soils may be considered insufficient for soil fertility and crop growth (Greenland and Hayes, 1978), and could have statistically significant effect on crop yield and land productivity (Ihejiamaizu, 1999).

Exchangeable acidity (EA) which is closely associated with CEC was lower in the oil spill affected samples (0.53 and 0.3 cmol$^{(+)}$/kg for surface and sub soils, while those of the control samples were 0.41 and 0.43cmol$^{(+)}$/kg for surface and sub soils respectively)for the same reason. The effect of the oil spill on potassium (K) concentration is presented in Tables 8. The mean values are 2.94 and 1.45 cmol$^{(+)}$/kg for surface and sub soils, for the affected samples and of 3.29cmol$^{(+)}$/kg and 3.30cmol$^{(+)}$/kg for surface and sub soils for the control samples. The mean concentration of potassium (K) was slightly lower in the oil spillage affected areas (Tables 2 and 4). Lower concentration of potassium in the oil spill affected areas could retard plant growth, poor stem development (Atubi, 2006), and aid wilting (Brady and Weil, 1999).

A critical and comparative look at Tables 1 and 2 shows that oil spillage exerted the greater impact on the surface than the sub soils in the affected areas. This condition could stifle the germination, growth performance and yield of shallow rooting crops like tomatoes, pepper, maize, okra, beniseed, soybean and others, which are the major crops grown in the study area (Ihejiamaizu, 1999; Abii and Nwosu, 2009).

ISSN: 2456-8643

Table 1: Variation of Soil Physical Properties

Soil variables	Soil affected by pipeline project						Soil unaffected by pipeline project				t-TEST			Significance
	Sites	Anshua	Ugesa	Ber	Agula	Orwuatsaga	**Sites**	Genyi	Ayar	Tsuwe				
	No of Samples	6	6	4	4	4	**No of Samples**	8	8	8				
TOP SOILS		**Mean**		**Variance**				**Mean**	**Variance**		**t-stat**	**df**	**t-crit**	
% Sand		39.93		5.29				32.82	2.11		12.80	39	2.02	SD
% Silt		16.41		0.77				12.55	1.68		12.07	40	2.02	SD
% Clay		43.66		4.57				54.63	3.08		-19.42	44	2.02	NSD
(^{0}C) Temperature		31.31		0.16				30.09	0.33		8.64	41	1.68	SD
% Moisture Content		7.46		2.22				4.24	3.51		6.58	44	1.68	SD
SUB SOILS		**Mean**		**Variance**				**Mean**	**Variance**		**t-stat**	**df**	**t-crit**	**Significance**
% Sand		40.91		4.26				35.92	10.41		6.39	39	2.02	SD
% Silt		18.28		6.52				12.78	2.31		9.08	37	2.03	SD
% Clay		40.81		7.38				51.31	8.24		-13.01	46	2.01	NSD
(^{0}C) Temperature		30.92		0.17				29.32	0.05		16.70	36	2.03	SD
% Moisture Content		9.89		0.94				7.06	1.43		9.01	44	2.02	SD

SD – Significant Difference.

NSD – No Significant Difference

Alpha Level= 0.05.

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Table 2: Variation of Soil Chemical Properties

Soil variables		Soil affected by pipeline						Soil unaffected by pipeline				t-TEST		Significance
	Site	Anshua	Ugesa	Ber	Agula	Orwuatsaga	**Site**	Genyi	Ayar	Tsuwe				
	No of Samples	6	6	4	4	4	**No of Samples**	8	8	8				
TOP SOILS		**Mean**		**Variance**				**Mean**	**Variance**		**t-stat**	**Df**	**t-crit**	
Ca (cmol$^{(+)}$/kg)		7.00		0.92				17.32	0.37		-44.57	39	1.69	NSD
K (cmol$^{(+)}$/kg)		2.94		0.42				3.29	0.23		-2.13	42	1.68	NSD
Na (cmol$^{(+)}$/kg)		1.43		0.03				1.35	0.01		2.07	39	2.02	SD
Mg (cmol$^{(+)}$/kg)		3.25		0.38				3.46	0.27		-1.31	45	1.68	NSD
Ea (cmol$^{(+)}$/kg)		0.53		0.03				0.41	0.00		3.45	27	1.70	SD
CEC (cmol$^{(+)}$/kg)		14.64		4.70				25.20	273		-18.92	43	1.68	NSD
Zn (mg/kg)		2.85		0.24				1.35	0.05		13.56	32	1.69	SD
NO_3-N (mg/kg)		31.15		4.22				52.14	10.21		-27.07	39	1.69	NSD
Fe (mg/kg)		24.44		4.34				17.09	0.76		15.93	31	1.70	SD
P (mg/kg)		26.72		37.36				18.57	1.59		6.40	25	1.71	SD
Pb (mg/kg)		0.16		0.00				0.13	0.00		6.79	45	1.68	SD
Cu (mg/kg)		1.41		0.02				0.88	0.01		15.39	46	1.68	SD
THC (mg/kg)		4871.25		307437.5				1.75	0.16		43.02	23	1.71	SD
Ni (mg/kg)		0.07		0.00				0.01	0.00		14.08	34	1.69	SD
Cd (mg/kg)		0.15		0.00				0.12	0.00		7.92	46	2.01	SD
Org Matter (%)		3.63		0.47				1.34	0.04		15.68	27	2.05	SD
Electric Conductivity (Ds/m)		18.46		11.09				8.10	1.17		14.49	28	2.05	SD
pH		7.43		0.03				8.53	0.01		-31.00	33	2.03	NSD
SUB SOILS		**Mean**		**Variance**				**Mean**	**Variance**		**t-stat**	**Df**	**t-crit**	**Significance**
Ca (cmol$^{(+)}$/kg)		4.72		0.01				16.8	1.10		-56.18	23	2.07	NSD
K (cmol$^{(+)}$/kg)		1.46		0.17				3.33	0.29		-13.63	43	2.02	NSD
Na (cmol$^{(+)}$/kg)		1.17		0.00				1.28	0.00		-7.55	39	2.02	NSD
Mg (cmol$^{(+)}$/kg)		2.27		0.01				3.24	0.37		-7.69	25	2.06	NSD
Ea (cmol$^{(+)}$/kg)		0.3		0.00				0.43	0.00		-9.46	31	2.04	NSD
CEC (cmol$^{(+)}$/kg)		9.87		3.55				25.06	3.46		-28.08	46	2.01	NSD
Zn (mg/kg)		2.87		0.18				1.2	0.01		18.96	24	2.06	SD
NO_3-N (mg/kg)		32.34		4.87				53.5	13.12		-24.42	38	2.02	NSD
Fe (mg/kg)		25.9		5.26				19.54	0.46		13.03	27	2.05	SD
P (mg/kg)		27.92		43.06				19.6	4.18		5.93	27	2.05	SD
Pb (mg/kg)		0.19		0				0.11	0.00		15.73	31	2.04	SD
Cu (mg/kg)		1.34		0.01				0.94	0.02		11.98	43	2.02	SD
THC (mg/kg)		4518.3		461597.1				0.72	0.01		32.58	23	2.07	SD
Ni (mg/kg)		0.05		0.00				0.01	0.00		16.58	44	2.02	SD
Cd (mg/kg)		0.15		0				0.11	0.00		8.26	35	2.03	SD
Org Matter (%)		3.24		0.27				1.03	0.02		20.17	27	2.05	SD
Electric Conductivity (Ds/m)		20.04		14.38				9.32	0.63		13.56	25	2.06	SD
pH		7.35		0.02				8.29	0.01		-26.48	34	2.03	NSD

SD – Significant Difference, NSD – No Significant Difference, Alpha Level = 0.05

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Table 3: Physical characteristics of soil profile pit samples in the study area

Horizon symbol	Horizon depth (cm)	% Sand	% Silt	% Clay	Colour	Texture	(^{0}C) Temperature	% Moisture content
Soil Profile Pit no PA1 (soil affected by oil spillage at Anshua)								
A_P1	0-30	48.8	15.2	36	VERY DARK BROUN	SCL	32	8.5
A2	30-90	49	14	37	DARK BROWN	SCL	31.5	9.8
Bt_1	90-120	16.3	27.5	56.2	REDDISH BROWN	CL	31	18.62
Bt2	120-130	7.2	28.6	64.2	REDDISH BROWN	C	31	16.92
Soil Profile Pit no PA2 (soil affected by oil spillage at Agula)								
A_P1	0 – 30	49.2	14.8	36	VERY DARK BROWN	SCL	31.5	8.22
A2	30 – 90	50	14	36	DARK BROWN	SC	31	8.94
Bt_1	90 – 125	15.8	29.4	54.8	REDDISH BROWN	CL	30	19.18
Bt2	125-140	9.8	27.8	62.4	REDDISH BROWN	C	30	19.2
Soil Profile Pit no PU (soil unaffected by oil spillage at Genyi)								
A_P1	0-40	28.8	14	57.2	BROWN	C	30.5	2.88
A2	40-90	32.4	14.8	52.8	BRIGHT BROWN	C	30.5	4
Bt_1	90-130	21.4	48.2	30.4	REDDISH BROWN	CL	30	8.64
Bt2	130-150	22.2	47.8	30	REDDISH BROWN	CL	30.5	8.42

Key: SC=Sandy Clay; SCL= Sandy Clay Loam; C= clay; CL =Clay Loam; L= Loam

Vol. 2, No. 05; 2017

ISSN: 2456-8643

Table 4: Chemical characteristics of the soil profile pit samples in the study area

Horizon symbol	Ca (cmol$^{(+)}$/kg)	K	Na	Mg	Ea	CEC	Zn	NO_3 - N	Fe (mg/kg)	P	Pb	Cu	THC (mg/kg)	Ni (mg/kg)	Cd (mg/kg)	Organic Matter (%)	Electric Conductivity (Ds/m)	pH
Soil Profile Pit no. PA_1 (soil affected by oil spillage at Anhua)																		
Ap_1	8.4	3.25	1.48	3.78	0.61	16.80	3.38	28.2	27.5	34.6	0.19	1.54	5830	0.09	0.17	4.61	22.4	7.55
A_2	6.8	3.26	1.47	3.6	0.53	15.00	3.34	26.4	27	32.8	0.17	1.48	4260	0.07	0.14	4.33	28.6	7.5
Bt_1	4.2	2.42	1.34	3.22	0.46	14.00	3.12	24.8	21.8	30.8	0.15	1.4	3680	0.07	0.13	4.27	27.5	6.2
Bt_2	7.4	1.86	1.26	3.14	0.39	12.50	2.88	22.4	1.84	30.7	0.14	1.14	3450	0.05	0.12	3.16	26.4	6.4
MEAN	**6.70**	**2.70**	**1.39**	**3.44**	**0.50**	**14.58**	**3.18**	**25.45**	**19.54**	**32.23**	**0.16**	**1.39**	**4305.00**	**0.07**	**0.14**	**4.09**	**26.225**	**6.9125**
VARIANCE	**3.21**	**0.47**	**0.01**	**0.09**	**0.01**	**3.26**	**0.05**	**6.06**	**145.80**	**3.44**	**0.00**	**0.03**	**1149766.67**	**0.00**	**0.00**	**0.41**	**7.309167**	**0.507292**
Soil Profile Pit no. PA_2 (soil affected by oil spillage at Agula)																		
Ap_1	8.6	3.14	1.46	3.84	0.71	16.44	3.63	29.8	26.9	33.8	0.18	1.68	5620	0.08	0.15	3.23	23.7	7.6
A_2	7.4	3.16	1.4	3.52	0.57	15.93	3.42	27.6	26.1	32	0.16	1.44	4650	0.07	0.13	3.75	26.5	7.55
Bt_1	6.4	2.52	1.32	3.32	0.37	13.93	3.34	25.4	21	31.4	0.14	1.32	3840	0.06	0.12	3.02	28.6	6.4
Bt_2	5.2	1.92	1.28	3.18	0.34	11.92	2.86	21.8	20.8	30.2	0.13	1.18	3680	0.04	0.1	2.24	27.4	6.4
MEAN	**6.90**	**2.94**	**1.37**	**3.47**	**0.50**	**14.56**	**3.31**	**26.15**	**23.70**	**31.85**	**0.15**	**1.41**	**4447.50**	**0.06**	**0.13**	**3.06**	**26.55**	**6.9875**
VARIANCE	**2.09**	**0.90**	**0.01**	**0.08**	**0.03**	**4.26**	**0.11**	**11.64**	**10.57**	**2.25**	**0.00**	**0.04**	**791291.67**	**0.00**	**0.00**	**0.39**	**4.35**	**0.460625**
Soil Profile Pit no.PU (soil unaffected by oil spillage at Genyi)																		
Ap_1	18.2	3.48	1.28	3.9	0.46	28.48	1.36	56.8	14.2	20.6	0.12	0.84	1.6	0.02	0.14	2.15	9.62	8.6
A_2	16.4	3.24	1.24	3.7	0.45	25.03	1.24	56.2	16.8	18.4	0.11	0.76	1.4	0.01	0.1	1.27	10.4	8.4
Bt_1	14.8	2.82	1.23	3.4	0.4	22.65	1.16	50.8	16	17.6	0.11	0.75	1.4	0	0.1	1.17	8.62	7.2
Bt_2	13.4	2.44	1.2	3.3	0.37	20.71	1.12	46.4	17.2	17	0.1	0.68	1.2	0	0.07	1.7	8.42	7.2
MEAN	**15.70**	**3.00**	**1.24**	**3.58**	**0.42**	**24.22**	**1.22**	**52.55**	**16.05**	**18.40**	**0.11**	**0.76**	**1.40**	**0.01**	**0.10**	**1.57**	**9.265**	**7.85**
VARIANCE	**4.28**	**0.21**	**0.00**	**0.08**	**0.00**	**11.20**	**0.01**	**24.09**	**1.77**	**2.48**	**0.00**	**0.00**	**0.03**	**0.00**	**0.00**	**0.20**	**0.8481**	**0.57**

Key: PA = Affected Soil Profile Pit Sample; PU = Control Soil Profile Pit Sample; PA1 = Affected Soil Profile Pit Sample at Anshua; PA2 = Affected Soil Profile Pit Sample at Agula; PU = Soil Profile Pit at Genyi; Ap1 – Ap1 horizon; A2 –A2 horizon; Bt1 – Bt1 horizon; Bt2 – Bt2 ho

Vol. 2, No. 05; 2017

ISSN: 2456-8643

Soil profile investigations

The physical and chemical characteristics of soil profile samples investigated in this study are explained below.

The results as presented in Tables 3 and 4 shows that the values of electrical conductivity (EC), moisture content, temperature, total hydrocarbon content (THC), organic matter (OM), available phosphorus, sodium, zinc, heavy metals (Ni, Fe, Cu, Cd, and Pb), and percentage of sand were higher in the oil spill affected soil profile samples. This agreed with the significance in the surface and sub soils test results presented in Tables 1 and 2.Similarly, the values of pH, CEC, potassium, nitrates, calcium and magnesium were low in the oil spill affected soil profile pit samples. This also agreed with the results of the significant tests for the surface and sub soils presented in Tables 1 and 2. The soil texture in the soil profile pit samples from both the affected and unaffected areas were generally clayey, which was in agreement with the surface and sub soil investigation. These results also agreed with the results obtained on similar research works by Olowolafe, (2008); Olowolafe and Dund, (2000); and Osuji and Nwoye, (2007). The soil profile tables also showed that, the values of the elements above were decreasing in the various horizons. A general look at the soil profile result (Tables 10 and 11) showed that the oil spillage exerted the greater impact on the soils of the upper horizons than those of the lower horizons. This also agreed with the difference between the values of the concentration of the elements in the surface and sub soil samples presented in Tables 1 and 2. This condition could indeed stifle the germination, growth performance and yield of most of the crops grown within the study areas which are mainly shallow rooting (Anoliefo and Nwoko, 1994; Abii and Nwosu, 2009).

Table 3 showed that the colours of the soils in the upper horizons (Ap1 and A2) in the oil spill affected sites are very dark brown and dark brown as against brown and bright brown in the Ap1 and A2 horizons in the control sites. These discoveries may be due to the influences of oil pollution in the affected areas (Baruaet al., 2011). Physical observation of the spillage site at Anshua and Tse Agula (Plates 1 and 2) indicated that the soils were visibly soaked with hydrocarbon, dark coloured with characteristic hydrocarbon (diesel especially) odour and with attendant loss of aggregative properties. This agreed with the results of a similar work carried out in India by Baruaet al., (2011).

Crude oil contamination of soil has been reported to cause reduction in the germination, growth and their performance and even yields of crops (Anoliefo et al., 2006; Vwioko et al., 2006.). Oil contamination of soil has also been reported to limit normal diffusion processes thereby reducing the level of some nutrients in the soil (Agbogidi and Egbuchua, 2010). The unavailability of mineral nutrients in soils as a result of oil contamination has been reported to cause such harmful effects as leaf chlorosis, necrosis, growth stunting in shoots and roots leading to a reduction in biomass accumulation (Agbogidi, 2011). This was evident in the oil spill sites at Anshua and Tse Agula in this project (Plates 1 and 2). A careful and comparative look at Tables 1 and 2 showed that the oil spills exerted the greater impact on the surface soils than the sub soils. This condition may stifle the germination, growth performance and yield of crops that are not deeply rooted (Anoliefo and Nwoko, 1994).

CONCLUSIONS

This study revealed that petroleum products from oil spills from the NNPC pipeline project was certainly responsible for the alterations of soil physico-chemical properties in the environment of some communities within Ugee, Mbasombo and Mbalom council wards in Gwer L.G.A in Benue State. The effects of oil spillage on these and other soil nutrient variables on the soils of the study area indicated that, the environment of these Masev communities were adversely affected by the NNPC oil pipeline project.

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